ACCELERATED TEST METHOD FOR FERROELECTRIC MEMORY DEVICE

BACKGROUND OF THE INVENTION

The present invention relates to an accelerate test method for evaluating the endurance characteristic of a ferroelectric memory device comprising a capacitor element

5   having a ferroelectric film.

The endurance characteristic of a ferroelectric memory device comprising a capacitor element having a ferroelectric film (ferroelectric capacitor) is determined by a polarization inversion fatigue characteristic in which the remanence of the ferroelectric film decreases with the increase of the number of the occurrences of polarization inversion

10   in the ferroelectric film. For an accelerated test for evaluating the endurance characteristic, a method using only a voltage stress as an accelerated condition has been used conventionally.

Referring to FIGS. 5 and 6, a description will be given herein below to a first conventional embodiment (Japanese Laid-Open Patent Publication No. HEI 11-174026) in

15   which the endurance characteristic of a ferroelectric memory device is evaluated by an accelerated test method using only a voltage stress as an accelerated condition.

As shown in FIG. 5, a first regression line at a first polarization inversion voltage V_1 is determined by measuring remanences while gradually increasing the number N of the occurrences of polarization inversion at the first polarization inversion voltage V_1 in a

20   ferroelectric capacitor and plotting the number N of the occurrences of polarization inversion as abscissa and the decrease rate of the remanence as ordinate. Then, the foregoing operation is repeatedly performed even at a second polarization inversion voltage V_2 and a third polarization inversion voltage V_3, whereby a second regression line at the second polarization inversion voltage V_2 and a third regression line at the third

25   polarization inversion voltage V_3 are obtained.

1

Next, first, second, and third numbers NL_1, NL_2, and NL_3 of the occurrences of polarization inversion when the remanence reaches a specified decrease rate relative to the initial value thereof are obtained based on the first, second, and third regression lines.

Next, a regression line (hereinafter referred to as a linear model) shown in FIG. 6 which is represented by $\log NL = C - \alpha V$ (where each of C and α is a constant) is determined from the first, second, and third polarization inversion voltages V_1, V_2, and V_3 and from the first, second, and third numbers NL_1, NL_2, and NL_3 of the occurrences of polarization inversion.

Next, the number of the occurrences of polarization inversion indicative of an expected lifetime (e.g., the number NL_b of the occurrences of polarization inversion) under an accelerated condition (e.g., polarization inversion voltage V_b) which corresponds to the number of the occurrences of polarization inversion (e.g., the number NL_a of the occurrences of polarization inversion) indicative of an expected lifetime under an actual operating condition (e.g., polarization inversion voltage V_a) is determined from the linear model shown in FIG. 6.

By thus conducting an accelerated test on the ferroelectric memory device under accelerated conditions (the polarization inversion voltage V_b and the number NL_b of the occurrences of polarization inversion), the endurance characteristic thereof under actual operating conditions (the polarization inversion voltage V_a and the number NL_a of the occurrences of polarization inversion) is evaluated in a short period of time.

Referring to FIG. 7, a description will be given herein below to a second conventional embodiment (see Jpn. J. Appl. Phys., Vol. 33 (1994) pp. 3996-4002) in which the endurance characteristic of a ferroelectric memory device is evaluated by an accelerated test method using only a voltage stress as an accelerated condition.

FIG. 7 shows a relationship between the logarithm of the number of the

2

occurrences of polarization inversion and the reciprocal of a polarization inversion voltage.

First, the remanence is measured in the ferroelectric capacitor while gradually increasing the number Lc of the occurrences of polarization inversion at a specified polarization inversion voltage so that the number Lc of the occurrences of polarization inversion when the measured remanence reaches a specified decrease rate relative to the initial value of the remanence is determined. By repeatedly performing the foregoing sequence of processes for determining the number Lc of the occurrences of polarization inversion a plurality of times while changing the specified polarization inversion voltage, the number Lc of the occurrences of polarization inversion at each of the specified polarization inversion voltages is determined.

Next, the regression line (hereinafter referred to as a reciprocal model) shown in FIG. 7 which is represented by $logLc = B + d/V$ (where each of B and d is a constant) is determined by plotting the number (Lc) of the occurrences of polarization inversion as ordinate and the reciprocal of the specified polarization inversion voltage (V) as abscissa.

Next, from the reciprocal model of FIG. 7, the number of the occurrences of polarization inversion (e.g., the number Lc_e of the occurrences of polarization inversion) indicative of an expected lifetime under an accelerated condition (e.g., a polarization inversion voltage V_e) which corresponds to the number of the occurrences of polarization inversion (e.g., the number Lc_d of the occurrences of polarization inversion) indicative of an expected lifetime under an actual operating condition (e.g., a polarization inversion voltage V_d) is determined.

By thus conducting an accelerated test on the ferroelectric memory device under the accelerated conditions (the polarization inversion voltage V_e and the number Lc_e of the occurrences of polarization inversion), the endurance characteristic thereof under the actual operating conditions (the polarization inversion voltage V_d and the number Lc_d of the

3

occurrences of polarization inversion) is evaluated.

As a result of examining which one of the first conventional embodiment (linear model) and the second conventional embodiment (reciprocal model) each evaluating the endurance characteristic of a ferroelectric memory device by an accelerated test method using only the voltage stress as an accelerated condition performs an accelerated test which provides the endurance characteristic with a higher fittability to the actual endurance characteristic, the present inventors have concluded that the accelerated test using the reciprocal model provides the endurance characteristic with a higher fittability.

As a result of repeatedly performing an accelerated test on the endurance characteristic of a ferroelectric memory device by using the reciprocal model using only the voltage stress as an accelerated condition, however, the present inventors have found that even the accelerated test using the reciprocal model is unsatisfactory in terms of the fittability to the actual endurance characteristic of a ferroelectric memory device.

SUMMARY OF THE INVENTION

In view of the foregoing, it is therefore an object of the present invention to further improve the fittability of the evaluated endurance characteristic of a ferroelectric memory device comprising a capacitor element having a ferroelectric material to the actual endurance characteristic thereof.

To attain the object, the present inventors have further examined the reciprocal model. Although the foregoing conventional second embodiment discloses that the accelerated test using the reciprocal model is hardly influenced by a temperature stress, the present inventors doubted about the truth of the disclosure, repeatedly conducted experiments at various accelerated temperatures, and observed variations in remanence with the increase of the number of the occurrences of polarization inversion in the ferroelectric film of a ferroelectric capacitor (variations in remanence with time). As a

4

result, the present inventors found that the variations in remanence with the increase of the number of the occurrences of polarization inversion in the ferroelectric film are greatly affected by the accelerated temperatures, i.e., that the variations in remanence are largely dependent on the accelerated temperatures and also found that an accelerated test using the reciprocal model using only a voltage stress is lower in the degree of acceleration than an accelerated test using both the voltage stress and a temperature stress.

The present invention has been achieved based on the foregoing findings. Specifically, the present invention provides an accelerated test method for evaluating, under accelerated conditions (a temperature T_2 and a voltage V_2), an endurance characteristic of a ferroelectric memory device comprising a capacitor element having a ferroelectric film under actual operating conditions (a temperature T_1 and a voltage V_1), the method comprising the step of: deriving an acceleration factor (K) required to evaluate the endurance characteristic by using an expression:

$$\log K = A(1/V_1 - 1/V_2) + B(1/V_1T_1 - 1/V_2T_2)$$

(where each of A and B is a constant).

Since the accelerated test method for a ferroelectric memory device derives the acceleration factor (K) required to evaluate the endurance characteristic by using the first expression: $\log K = A(1/V_1 - 1/V_2) + B(1/V_1T_1 - 1/V_2T_2)$ which allows the calculation of the acceleration factor (K) considering the voltage stress and the temperature stress, the fittability of the evaluated endurance characteristic of the ferroelectric memory device to the actual endurance characteristic thereof is improved greatly.

Preferably, the accelerated test method for a ferroelectric memory device further comprises the step of: determining the constants A and B by measuring polarization-inversion-voltage dependence of a remanence of the ferroelectric film which varies with increase of the number of occurrences of polarization inversion in the ferroelectric film at

5

each of a plurality of temperatures.

If the constants A and B in the first expression are thus determined by measuring the polarization-inversion-voltage dependence of the remanence of the ferroelectric film which varies with the increase of the number of the occurrences of polarization inversion in the ferroelectric film at each of the plurality of temperatures, the accuracy of the first expression is increased so that the fittability of the evaluated endurance characteristic of the ferroelectric memory device to the actual endurance characteristic thereof is further improved.

Preferably, the accelerated test method for a ferroelectric memory device further comprises the step of: measuring a remanence of the ferroelectric film which varies with increase of the number of occurrences of polarization inversion in the ferroelectric film at each of a plurality of polarization inversion voltages (V) at a specified temperature (T), determining the number (Lc) of occurrences of polarization inversion when the determined remanence reaches a specified decrease rate relative to an initial value thereof, performing, a plurality of times, a sequence of processes for determining a constant α from the plurality of polarization inversion voltages (V), the numbers (Lc) of occurrences of polarization inversion, and an expression: $\log Lc = C + \alpha/V$ (where each of C and α is a constant), while varying the specified temperature (T), to determine a constant (α) at each of the specified temperatures (T), and determining the constants A and B from the constant (α) determined at each of the specified temperatures (T) and an expression: $\alpha = A + B/T$.

If the sequence of processes for determining the constant α from the plurality of polarization inversion voltages (V), the numbers (Lc) of the occurrences of polarization inversion, and the second expression : $\log Lc = C + \alpha/V$ (each of C and α is a constant) are thus performed a plurality of times, while varying the specified temperature (T), the constant (α) is thereby determined at each of the specified temperatures (T), and the

6

constants A and B in the first expression is determined from the constant (α) determined at each of the specified temperatures (T) and the third expression: $\alpha = A + B/T$, the accuracy of the first expression is increased so that the fittability of the evaluated endurance characteristic of the ferroelectric memory device to the actual endurance characteristic

5   thereof is further improved.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a graph showing a relationship between the logarithm of the number of the occurrences of polarization inversion and the reciprocal of a polarization inversion voltage at each of a plurality of temperatures;

10   FIG. 2 is a graph showing a relationship between a remanence and the number of the occurrences of polarization inversion at each of a plurality of polarization inversion voltages;

FIG. 3 is a graph showing a relationship between the logarithm of the number of the occurrences of polarization inversion and the reciprocal of a polarization inversion

15   voltage at each of a plurality of temperatures;

FIG. 4 is a graph showing a relationship between a constant and the reciprocal of a temperature;

FIG. 5 is a graph showing a relationship between the decrease rate of a remanence and the logarithm of the number of the occurrences of polarization inversion in a first

20   conventional embodiment;

FIG. 6 is a graph showing a linear model in the first conventional embodiment; and

FIG. 7 is a graph showing a reciprocal model in a second conventional embodiment.

7

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIGS. **1** to **4**, an embodiment of the present invention will be described herein below.

In an accelerated test for evaluating, under an accelerated condition, the endurance characteristic of a ferroelectric memory device comprising a capacitor element having a ferroelectric film (ferroelectric capacitor) under an actual operating condition, it is necessary to predetermine an acceleration factor (K) required to evaluate the endurance characteristic. Since an accelerated test method according to the present invention uses both a voltage stress and a temperature stress, it is necessary for the determination of the acceleration factor to determine a model considering the degree of the influence of the endurance characteristic of the ferroelectric memory device comprising the ferroelectric capacitor by voltage acceleration and temperature acceleration, i.e., the polarization-inversion-voltage dependence and temperature dependence of the endurance characteristic of the ferroelectric memory device.

The endurance characteristic of the ferroelectric memory device comprising the ferroelectric capacitor is determined by the polarization inversion fatigue characteristic in which the remanence of the ferroelectric film decreases with the increase of the number of the occurrences of polarization inversion in the ferroelectric film of the ferroelectric capacitor. Therefore, the model considering the polarization-inversion-voltage dependence and temperature dependence of the endurance characteristic of the ferroelectric memory device can be determined by measuring the polarization-inversion-voltage dependence and temperature dependence of the polarization inversion fatigue characteristic in which the remanence of the ferroelectric film decreases with the increase of the number of the occurrences of polarization inversion in the ferroelectric film of the ferroelectric capacitor.

Based on the foregoing concept, the present inventors have determined the model

8

as follows.

First, in a ferroelectric capacitor, the polarization-inversion-voltage dependence of the remanence of a ferroelectric film composing the ferroelectric capacitor which varies with the increase of the number of the occurrences of polarization inversion in the ferroelectric film is measured at each of first, second, third, and fourth temperatures T_1, T_2, T_3, and T_4 ($T_1 < T_2 < T_3 < T_4$).

Specifically, the number (Lc) of the occurrences of polarization inversion when the remanence at each of first, second, third, and fourth temperatures T_1, T_2, T_3, and T_4 reaches a specified decrease rate relative to the initial value thereof is determined at each of a plurality of polarization inversion voltages (V). Then, the determined number (Lc) of the occurrences of polarization inversion is plotted as ordinate and the plurality of polarization inversion voltages (V) are plotted as abscissa, whereby the reciprocal model shown in FIG. 1 which is represented by

$$\log Lc = C + \alpha/V \qquad \text{... Expression (1)}$$

(where each of C and α is a constant) is determined at each of the first, second, third, and fourth temperatures T_1, T_2, T_3, and T_4.

The present inventors have found that the gradient of a straight line representing the polarization-inversion-voltage dependence of the change of the remanence (the change with time of the remanence) with the increase of the number (Lc) of the occurrences of polarization inversion in the ferroelectric film is different at each of the first, second, third, and fourth temperatures T_1, T_2, T_3, and T_4. In other words, the present inventors have found that the polarization-inversion-voltage dependence of the change of the remanence with the increase of the number (Lc) of the occurrences of polarization inversion in the

9

ferroelectric film is largely dependent on accelerated temperatures (T).

Accordingly, α_1 as a constant (α) corresponding to the first temperature T_1 can be determined from the number (Lc) of the occurrences of polarization inversion when the remanence calculated at each of the plurality of polarization inversion voltages (V) at the

5   first temperature T_1 reaches a specified decrease rate relative to the initial value thereof, the plurality of polarization inversion voltages (V), and Expression (1). Likewise, α_2, α_3, and α_4 as constants (α) corresponding to the second, third, and fourth temperatures T_2, T_3, and T_4 can be determined ($\alpha_1 > \alpha_2 > \alpha_3 > \alpha_4$).

Thus, it will be understood that the polarization-inversion-voltage dependence of

10   the remanence of a ferroelectric film which changes with the increase of the number (Lc) of the occurrences of the ferroelectric film is represented by the reciprocal model in which the logarithm of the number (Lc) of the occurrences of polarization inversion and the reciprocal of the polarization inversion voltage (V) are regressed with a straight line, as shown in FIG. 1, and that the polarization-inversion-voltage dependence of the remanence

15   of the ferroelectric film which changes with the increase of the number (Lc) of the occurrences of polarization inversion in the ferroelectric film is largely dependent on the accelerated temperature (T).

Next, an acceleration-factor calculating expression for calculating an acceleration factor (K) required to evaluate, under accelerated conditions, the endurance characteristic

20   of a ferroelectric memory device having a ferroelectric capacitor under actual operating conditions is derived.

First, since the constant (α) in Expression (1) changes at each of measurement temperatures (T) so that a relational expression between the constant (α) and the temperature (T) becomes necessary. The relational expression between the constant (α) and

25   the temperature (T) is determined from the following fact.

That is, a relationship regressed with a straight line is established between the logarithm of a dielectric breakdown lifetime and the reciprocal of a voltage in the ferroelectric capacitor. On the other hand, the endurance characteristic of the ferroelectric memory device has a correlation with the leakage current value of the ferroelectric capacitor and is more excellent as the leakage current value is smaller. The two phenomena indicate that the mechanism of polarization inversion fatigue in which the remanence of the ferroelectric film decreases with an increase in the number (Lc) of the occurrences of polarization inversion in the ferroelectric film is closely related to the dielectric characteristic.

With regard to the dielectric breakdown of a common insulating film including a ferroelectric film, it has been known that the voltage dependence of the dielectric breakdown of, e.g., a silicon oxide film changes with temperature. It has been reported that the relationship between the gradient (γ) of the voltage dependence and the temperature (T) is represented by:

$$\gamma = A + B/T \quad \text{(where each of A and B is a constant)} \quad \text{... Expression (2).}$$

(see "Acceleration Factors for Thin Oxide Breakdown," pp.1903-1908, J.W. McPherson and D.A. Baglee: J. Electrochem. Soc., (1985)).

If consideration is given to the fact that the mechanism of polarization inversion fatigue is closely related to the dielectric characteristic and to the fact that the voltage dependence of the dielectric breakdown of a common insulating film including a ferroelectric film changes with temperature, as described above, it can be assumed that the relationship represented by Expression (2) is also applicable to the dielectric breakdown of the ferroelectric capacitor.

In other words, it can be assumed that the relationship represented by:

$$\alpha = A + B/T \quad \text{(where each of A and B is a constant)} \qquad \text{... Expression (3)}$$

is established between the gradient (α) of the voltage dependence and the temperature (T) also for the voltage dependence of the endurance characteristic of a ferroelectric memory device comprising a ferroelectric capacitor, which is closely related to the dielectric characteristic, in the same manner as in Expression (2).

If L_1 represents the endurance characteristic lifetime under the actual operating conditions (the temperature T_1 and the polarization inversion voltage V_1) of the ferroelectric memory device comprising the ferroelectric capacitor and L_2 represents the endurance characteristic lifetime under the accelerated conditions (the temperature T_2 and the polarization inversion voltage V_2) thereof ($T_1 < T_2$, $V_1 < V_2$), the acceleration factor (K) required to evaluate, under the accelerated conditions (the temperature T_2 and the polarization inversion voltage V_2), the endurance characteristic of the ferroelectric memory device under the actual operating conditions (the temperature T_1 and the polarization inversion voltage V_1) can be derived from Expressions (1) and (3) based on the acceleration-factor calculating expression represented by:

$$\log K = \log(L_1/L_2) = A(1/V_1 - 1/V_2) + B(1/V_1 T_1 - 1/V_2 T_2) \quad \text{... Expression (4).}$$

The constants A and B in Expression (4) as the acceleration-factor calculating expression can be determined by measuring, at a plurality of temperatures (T), the polarity-inversion-voltage dependence of the remanence of a ferroelectric film which varies with the increase of the number (Lc) of the occurrences of polarization inversion in the

12

ferroelectric film. Specifically, the constants A and B can be determined from the constants α_1, α_2, α_3, and α_4 corresponding to the first, second, third, and fourth temperatures T_1, T_2, T_3, and T_4 that have been calculated in consideration of Expression (1) and from Expression (3): $\alpha = A + B/T$.

5   Thus, since the present embodiment derives the acceleration factor (K) required to evaluate the endurance characteristic of a ferroelectric memory device by using Expression (4): $\log K = A(1/V_1 - 1/V_2) + B(1/V_1 T_1 - 1/V_2 T_2)$ as the acceleration-factor calculating expression which allows calculation considering a voltage stress and a temperature stress, the fittability of the evaluated endurance characteristic of the ferroelectric memory device

10   to the actual endurance characteristic thereof is improved significantly. As a result, an accelerated test method which allows higher-precision and more efficient evaluation of the endurance characteristic of the ferroelectric memory device is provided. If the constants A and B in Expression (4) as the acceleration-factor calculating expression are determined by measuring, at each of a plurality of temperatures (T), the polarity-inversion-voltage

15   dependence of the remanence of a ferroelectric film which varies with the increase of the number of the occurrences of polarity inversion in the ferroelectric film, the accuracy of Expression (4) as the acceleration-factor calculating expression is increased so that the fittability of the evaluated endurance characteristic of the ferroelectric memory device to the actual endurance characteristic thereof is further improved.

20   A description will be given herein below to the accelerated test method according to the present embodiment by using a specific example.

    The description will be given first to a method for determining the constants A and B in Expression (4) as the acceleration-factor calculating expression to calculate an acceleration factor (K) required to evaluate the endurance characteristic of a ferroelectric

25   memory device under actual operating conditions.

Specifically, the polarity-inversion-voltage dependence of the remanence (Pnv) of

a ferroelectric film which varies with the increase of the number (Lc) of the occurrences of

polarity inversion in the ferroelectric film composing a ferroelectric capacitor are measured

at each of temperatures of 85 °C, 100 °C, 110 °C, and 125 °C. As for the temperatures, they

5   are not limited to the foregoing ones provided that two or more different temperatures are

used.

FIG. 2 shows the remanence (Pnv) of the ferroelectric film composing the

ferroelectric capacitor which varies, at a temperature of 125 °C, with the increase of the

number (Lc) of the occurrences of polarization inversion in the ferroelectric film at each of

10   the polarization inversion voltages (V) in the range of 3 V to 7 V. Although the voltages in

the range of 3 V to 7V are used as the polarization inversion voltages (V), as shown in FIG.

2, the polarization inversion voltages (V) are not limited to the voltages in the foregoing

range. The remanences (Pnv) that have been normalized with a predetermined initial value

are plotted as ordinate, while the numbers (Lc) of the occurrences of polarization inversion

15   are plotted as abscissa.

As shown in FIG. 2, the endurance characteristic lifetime (Lc) at each of the

polarization inversion voltages (V) is determined by considering the number (Lc) of the

occurrences of polarization inversion when the decrease rate of the remanence (Pnv)

relative to the initial value thereof becomes 10% as the endurance characteristic lifetime

20   (Lc). Although the number (Lc) of the occurrences of polarization inversion when the

decrease rate of the remanence (Pnv) relative the initial value thereof becomes 10% is

considered as the endurance characteristic lifetime (Lc) in the present embodiment, the

decrease rate may also be set to any percentage. In FIG. 2, the decrease rate (10%) of the

remanence (Pnv) relative to the initial value thereof is indicated by the solid line parallel

25   with the abscissa axis.

14

The number (Lc) of the occurrences of polarization inversion corresponding to the

point of intersection of the solid line indicative of the 10% decrease rate of the remanence

(Pnv) relative to the initial value thereof and the solid indicative of the remanence (Pnv) of

the ferroelectric film which varies with the increase of the number (Lc) of the occurrences

5   of polarization inversion in the ferroelectric film at each of the polarization inversion

voltages (V) becomes the endurance characteristic life (Lc), which is determined at each of

the polarization inversion voltages (V). The foregoing sequence of processes are repeatedly

performed also at each of the other temperatures of 85 °C, 100 °C, and 110 °C so that the

endurance characteristic lifetime (Lc) at each of the polarization inversion voltages (V) is

10   determined.

Next, the respective numbers (Lc) of the occurrences of polarization inversion

determined in the manner described above at the temperatures of 125 °C, 85 °C, 100 °C,

and 110 °C are plotted as ordinate and the reciprocals of the polarization inversion voltages

(V) in the voltage range of 3 to 7 V are plotted as abscissa, whereby the reciprocal model

15   represented by Expression (1): $\log Lc = C + \alpha/V$ is determined, as shown in FIG. **3**. From

the respective numbers (Lc) of the occurrences of polarization inversion determined at the

temperatures of 125 °C , 85 °C, 100 °C, and 110 °C, the plurality of polarization inversion

voltages (V), and Expression (1): $\log Lc = C + \alpha/V$, respective constants (α) at the

temperatures of 125 °C , 85 °C, 100 °C, and 110 °C are determined. As a result, 16.4, 15.1,

20   14.3, and 13.2 can be determined as the respective constants (α) corresponding to the

temperatures of 85 °C, 100 °C, 110 °C, and 125 °C.

Next, as shown in FIG. **4**, constants A and B are determined from Expression (3):

$\alpha = A + B/T$ and the respective constants of 16.4, 15.1, 14.3, and 13.2 corresponding to the

temperatures of 85 °C, 100 °C, 110 °C, and 125 °C. Consequently, the constant A = -15.464

25   and the constant A = 11404 are satisfied so that Expression (4) as the acceleration-factor

calculating expression is completed by using the constants A and B.

Next, the number (Lc) of the occurrences of polarization inversion indicative of an expected lifetime under accelerated conditions, which corresponds to the number (Lc) of the occurrences of polarization inversion indicative of an expected lifetime under actual conditions, is determined based on the accelerated-factor calculating expression that has been completed. Specifically, if the acceleration factor (K) when an accelerated test is performed at a polarization inversion voltage of 7.5 V and a temperature of 125 °C as accelerated conditions corresponding to evaluation which guarantees 10^{12} times as the number of the occurrences of polarization inversion at a polarization inversion voltage of, e.g., 3.3 V and a temperature of, e.g., 85 °C as actual operating conditions is calculated, the acceleration factor K = 1615 is determined.

By using the acceleration-factor calculating expression in which the acceleration factor K = 1615 has been substituted, about 6×10^8 times is obtainable as the number of the occurrences of polarization inversion under accelerated conditions which corresponds to 10^{12} times as the number of times of polarization inversion to be guaranteed under actual operating conditions. Accordingly, the endurance characteristic corresponding to the case where the polarization inversion voltage is 3.3 V, the temperature is 85 °C, and the number of the occurrences of polarization inversion is 10^{12} as actual operating conditions can be determined by performing an accelerated test by setting the polarization inversion voltage to 7. 5V, the temperature to 125 °C, and the number of the occurrences of polarization inversion to 6×10^8 as accelerated conditions. This greatly improves the fittability of the evaluated endurance characteristic of the ferroelectric memory device to the actual endurance characteristic thereof and thereby provides an accelerated test method which allows more precise and more efficient evaluation of the endurance characteristic of a ferroelectric memory device.

16